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Telecommunications Policy for Regional Development[1]
Empirical Evidence in Europe

Roberta Capello and Peter Nijkamp

The telecommunications industry has been widely studied in American literature since the debate on the most appropriate market structure found appropriate ground for development. After the development of new technological potentials in both transmission and the switching equipment, which allowed enormous amounts of data (images, text and voice) to be transmitted on the same infrastructure, the US telecommunications market has moved from a monopolistic to a competitive profile. The choice to introduce competitive rules also has been made by the Japanese industry and, to much lesser extent, by one European nation, Britain.

While the best market solution for the telecommunications industry is still a matter of scientific dispute,[2] some agreement exists in Europe on the importance of telecommunications technologies for regional development. In Europe, the debate of the last two decades has put much attention on the role of telecommunications in economic development. In particular, a consensus has developed around the idea that telecommunications technologies are 'competitive weapons' upon which the competitiveness of firms and comparative advantage of regions will increasingly depend; industrial, regional and national economic systems which do not promptly adopt these technologies risk losing their positions in international markets.[3]

Acceptance of the strategic role played by advanced technologies in economic development during the 1980s is witnessed by the European Community's launch of a series of extensive programs in research and technology development intended to decrease regional disparities within the Community. Initiatives included:

• RACE (Research and Technology Development in Advanced Communications in Europe), which operated in two phases from 1987 to 1995. The follow-up program, from 1995 until 1998, is ACTS (Advanced Communications Technologies and Services).
• ESPRIT (European Strategic Program for Research and Development in Information Technologies). This program is funded until 1998.
• BRITE (Basic Research in Industrial Technologies), now merged with EURAM (European Research in Advanced Materials) and funded until 1998.
• STAR (This acronym translates to mean advanced telecommunications services for Europe's regions). The program concluded in 1991.
• DRIVE (Dedicated Road Infrastructure for Vehicle Safety in Europe). This program was replaced in 1994 with the Transport Telematics program, also funded until 1998.

Some of these programs were specifically developed to encourage economic development, with the implementation of telecommunications technologies in less favoured regions of the Community (called Objective 1 regions), such as the STAR program.

The importance of these technologies for economic development has stimulated analyses and studies on mechanisms for their adoption and diffusion. The relatively new branch of economics known as industrial economics has generated many interesting studies, emphasising the nature of telecommunications technologies and their intrinsic characteristic to be inter-related. Many of these studies have focused on diffusion mechanisms based on inter-related consumer preferences. In this context, the concept of network externalities has been identified, with the aim of explaining the economic rules governing the diffusion mechanisms of these strategic technologies.[4]

Up to now, these two economic theories—telecommunications as the motor for economic growth on the one hand and network externality theory on the other—seem to have been completely separated in the literature. The first theory mainly has been studied in the framework of regional economic theory: relatively more emphasis is put on the innovation aspect and on the consequences of the economic growth rate of firms and regions, and on the territorial transformation which occurs in economic activities when telecommunications technologies are introduced. By stimulating a shrinking of the distance between economic actors, telecommunications technologies may drive the economy towards a completely different spatial structure.

In contrast, the second field is studied more within the context of industrial economic theory and concerns the analysis of diffusion mechanisms among firms on the basis of standard economic rules and concepts, such as the 'externality' concept.

This paper attempts to bring these two fields together by providing an analysis of network externalities in the telecommunications sector and their effects on corporate and regional performance. It can be regarded as part of the general theoretical reflection on the role of telecommunications in economic development by emphasizing its importance for economic growth in the future.

However, the advantages derived from these technologies stem not only from the technological changes taking place in the sector but also from their nature as inter-related technologies. When a new subscriber joins the network, the marginal costs of his entry are lower than the marginal benefits he creates for people or firms already networked. This difference between marginal costs and benefits (in favour of the benefits) inevitably reflects on industrial performance and, via multiplicative effects, on regional performance. This phenomenon can be labelled the 'production-network externality effect'.

This paper develops that concept from an empirical point of view. The empirical analysis has been run in both the north and the south of Italy, two economically contrasting areas. Also, firms in the south of Italy are among those which have benefited from the European Community's STAR program. Our empirical analysis in the south may be interpreted as an evaluation of the effects that STAR has generated on the economic development of the south of Italy. As we will see, some rather interesting lessons can be learned at policy level. They can be useful for future regional intervention policies aiming at decreasing regional disparities with the help of advanced telecommunications technologies.

Empirical Analysis of Production Network Externalities

This section considers an extremely important issue, moving onto the measurement of production network externalities. All problems associated with our empirical analysis emerge in this section; indeed, the empirical test of what we argue theoretically is fraught with difficulties. One of the main problems is that in order to determine the impact of network externalities on

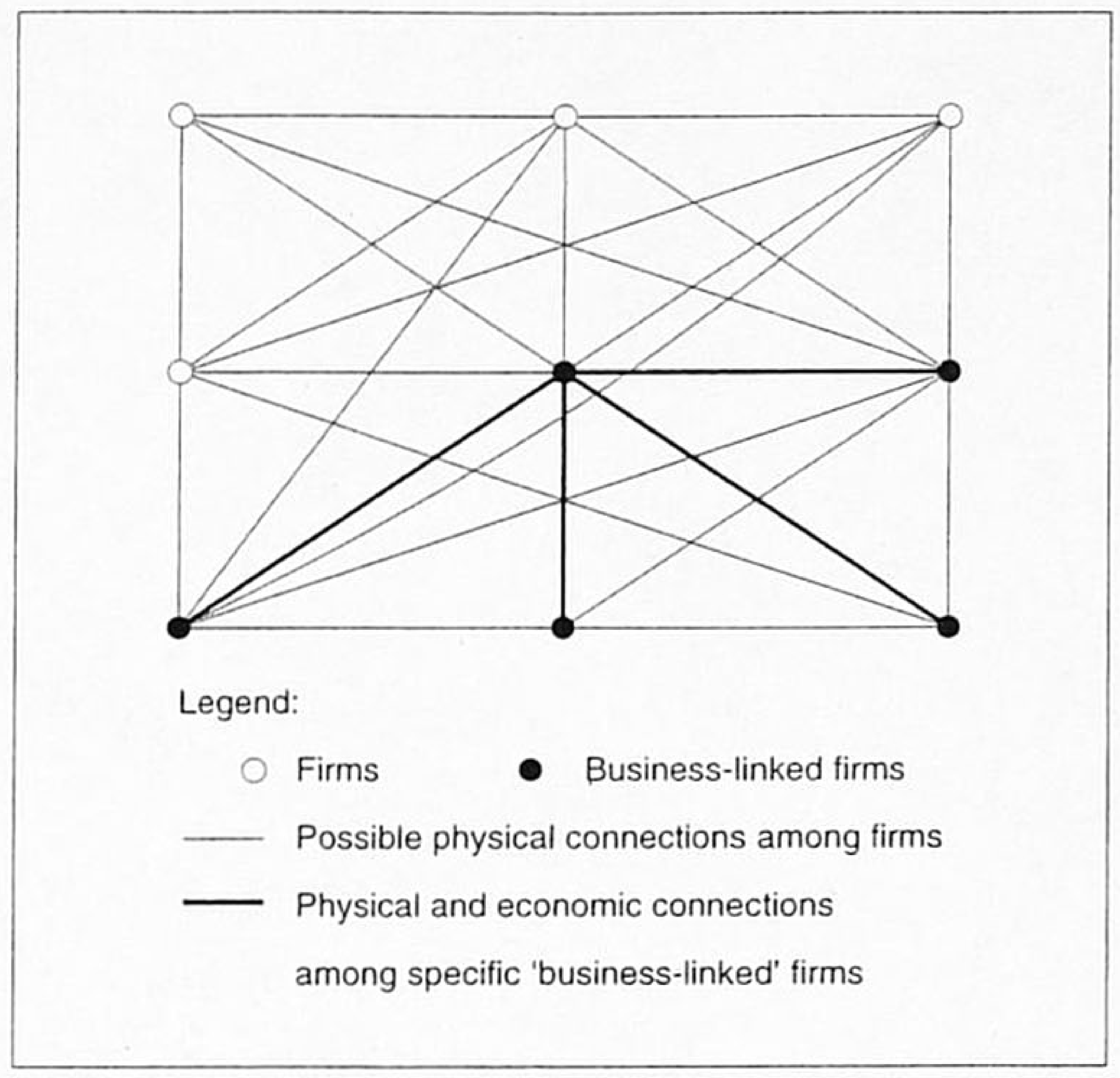

Figure 1. Schematic graph representing connectivity among firms

corporate and regional performance, it is necessary to have a reliable measuring rod of network externalities on one side and corporate and regional performance on the other. Moreover, production functions are influenced by a large number of elements which are similar to network externality effects, such as innovation effects and economies-of-scale effects, and disentangling specific network externality effects from all these other effects is not simple.

Our empirical analysis is carried out with a primary database, i.e. small and medium-sized firms belonging to different sectors, located in both the north and the south of Italy. For what concerns the south of Italy, interviews have been run among firms which had been involved in the EC program STAR and developed with the aim of decreasing regional disparities with the implementation of advanced and sophisticated telecommunications technologies. In this way, our empirical analysis is able to test to what extent the STAR program generated positive effects on the performance of firms and of regions.

The first part of this section is devoted to identification of our methodological approach to network externality measurement, while the results of the empirical exercise are set out in subsequent sections.

Conceptual and Methodological Approaches

Up to now in this study, the concept of network externalities has been explained in terms of the positive and increasingly intensive relation between the number of subscribers and the performance of firms. The higher the number of subscribers, the higher is the interest for a firm to join a network, and thus the better the effects on its performance. In reality, this definition is far too broad to explain the concept of network externality. In a static perspective, the interest of a firm is not to join the highest possible number of other firms connected via the network, but only the highest number of these firms directly or indirectly related to its own business activities. Thus, the decision to join the network is not simply related to the total number of firms already networked but to the number of specific business-linked firms already present in the network. The most obvious reason for entering a network is really the possibility of contacting relevant groups such as suppliers, customers or horizontally related firms in more efficient and quicker ways.

Connectivity is a measure of linkage between two or more firms in a network. Economic connectivity measures the economic relationships among firms. When these relationships are pursued via a telecommunications network, then we can also speak of physical connectivity. What we argue here is that there is a strong relationship between these two kinds of connectivity—in particular: physical connectivity has no reason to exist if economic connectivity does not exist.

Figure 1 is a schematic representation of physical connectivity with the use of graph theory. If, according to this theory, we represent firms as 'nodes' or 'vertices', and the physical links between them as 'arches' or 'edges', the outcome is an undirected graph of vertices and edges representing all potential physical (contact) lines that firms can entertain.

As we have just mentioned, the real interest of a particular firm, in a static world, is not to be linked to all other possible subscribers but to achieve full connectivity among only those firms related to its specific business. If we represent such firms in our graph with a bold vertex, and their economic relationships with other firms with bold edges, the real matrix of first order relationships will emerge. With this matrix it is possible to measure the proportion of real physical connectivity of a certain firm with regard to potential economic connectivity.

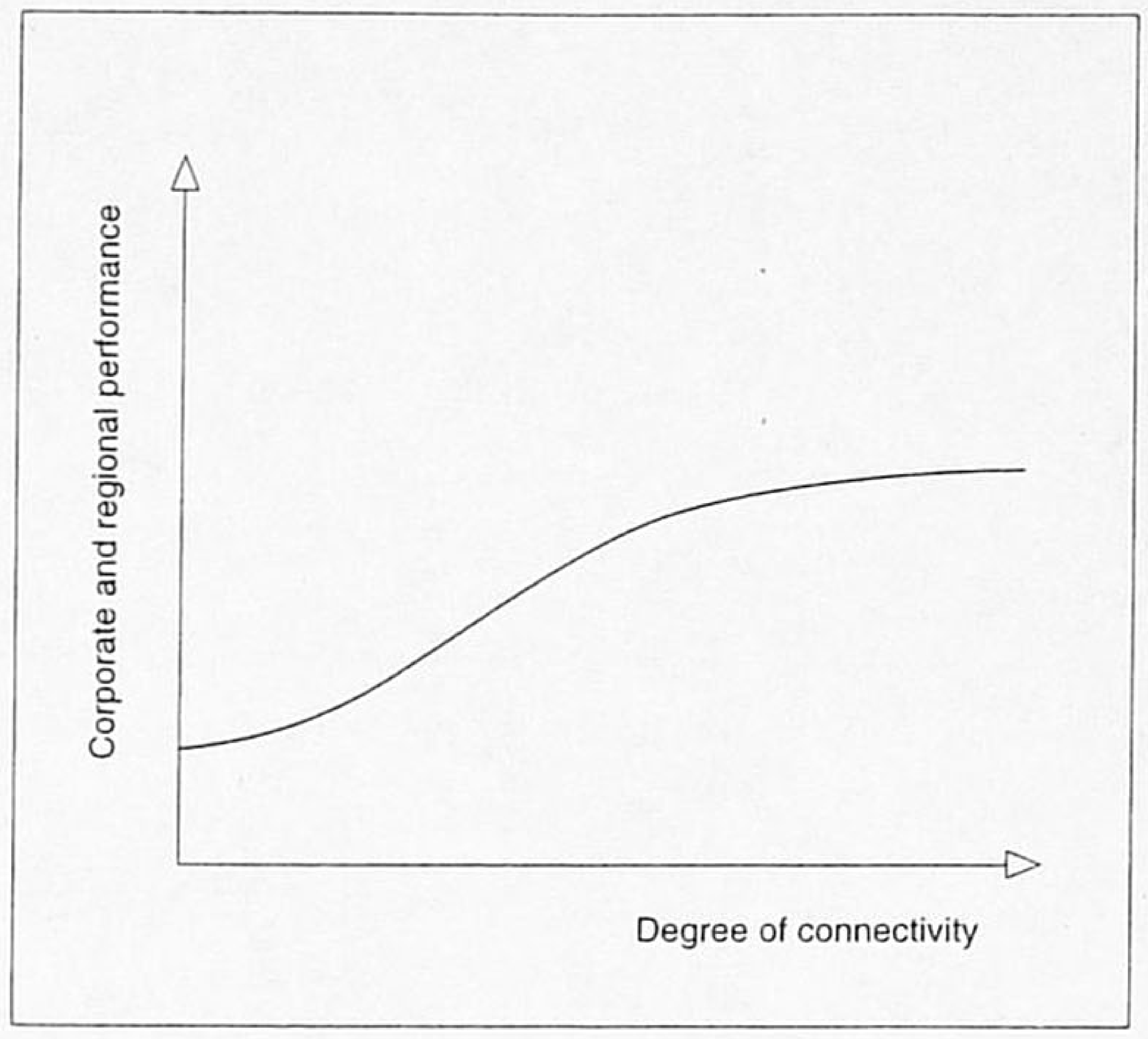

Figure 2. Increasing relationship between the degree of connectivity and corporate and regional performance

The physical connectivity is what generates network externalities. If the benefits a firm receives from physical connectivity is an increasing function of connectivity itself, then positive network externalities exist. This situation is represented by the positive derivative of the benefit function (Figure 2). Thus, so far we have described a way of measuring network externalities under the assumption of a static world. Hence, Figure 2 represents a possible way of measuring network externalities.

With the use of this method, various important analytical questions remain from a methodological point of view. The first open question is related to the measurement of network externalities via a connectivity index which measures only direct connections. In other words, only first order connectivity is measured via our method, while second and higher order connectivity links are not taken into account. The choice of measuring a first order connectivity index requires a careful choice. Second and third order connectivity loses the straightforward impact first order connectivity has on the production function because the most strategic relationships which matter for the productivity of a firm are the direct relationships with suppliers and customers (Porter, 1990). Relationships among suppliers or customers of the same firm, representing what we call second and higher order connectivity for that firm, do not have the same direct relation with the performance of that firm.

A second open question which arises from the method we have presented to measure network externalities is that a connectivity index does not take into account the intensity of information flows. While in the case of the first question above we might disregard the importance of indirect connections of a firm on its performance, in the second case it is more difficult to avoid the problem. The intensity of use of a network, and not only its access, inevitably has an impact on corporate performance. Thus, any kind of connectivity index has to be adjusted in order to include a measure of the intensity of use. This problem will be taken into account in our empirical analysis. This point also relates to the problem of distinguishing the effects of simple adoption and intense use of adoption.

The same approach can be applied to the regional level by identifying a link between a connectivity index (measuring the relationships that firms located in that region have with other firms within and outside the region) and a regional performance index. Using the same logic as in the case of the firm level, the connectivity among firms located in that region can be measured with the use of graph theory. A positive derivative between these two indices would explain the existence of network externality effects.

A third open question of this method is that the same weight in terms of economic importance is given to each link, although one can easily anticipate that each first order connection is bound to be of strategic importance for the firm, which could otherwise easily refuse the contact.

The same three limitations presented in the open questions above for the firm level are also true for the regional level. Again only first order relationships are taken into consideration but the intensity of use of these technologies is missing in this approach. As already discussed, the first and third open questions are not so crucial, since the most important connections influencing the performance of firms can be direct connections, all playing a role in the performance of firms. The second open question is the most crucial, since the intensity of use is extremely important for our analysis.

On the basis of the indications obtained by graph theory, a very simple connectivity index may be constructed, representing the ratio between the number of real connections to the total number of potential connections.[5] Although very simple in its formulation, it gives a measure of connection for each firm. The first open question mentioned before—querying whether it was the right approach to build a connectivity index only on first order connectivity—is not overcome by the way we build our index. However, we may be confident that second and third order connectivity has not the same effect as that of first order connectivity on the production function.

The second open question regarding the lack of a measure of intensity of flows is rather important, since it also reflects at an empirical level the distinctions between the effects that a rare or an intense use of these technologies has on the production function of firms. We will also run the empirical analysis for a connectivity index weighted with the use of these technologies, thus taking into account their intensity of use. As we will see in the next sections, this index leads to different empirical results.

The third open question concerns the same weight given to all connections or links. This limitation is not overcome by our connectivity index, although for our analysis it is not a strong limitation.

Despite the relative simple connectivity index used in the empirical analysis, the results obtained are satisfactory and provide evidence of the existence of production network externalities. The effects on the regional performance are measured in our empirical analysis as the sum of the positive effects that all firms located in the regions receive. Thus, we postulate that the higher the number of firms enjoying network externalities in a regions, the higher the regional performance.

The research methodology followed to test the existence of production network externalities is based on a correlation analysis between the connectivity index and the performance index. The analysis contains an initial estimation of the correlation coefficient between the 'row' connectivity index,[6] which measures the simple adoption of these technologies by firms, and the performance index, at the national level. Subsequently, the extent to which the inclusion of the regional dimension leads to better correlation coefficients will be analyzed. In this respect, we may expect stronger regional variations in the results for the two different areas.

The second step of the empirical analysis is devoted to introducing the 'frequency of use' variable into our framework. Thus, instead of measuring the correlation between the degree of adoption of these technologies and the performance of firms, the analysis is run between the use of these technologies and the performance of firms.

The second index for the empirical analysis is the performance index. A very simple performance index was chosen, which represents the labor productivity of each firm, defined as the ratio between the turnover of firms in 1991 and the number of employees in the same year. This measure may vary according to specific features of firms, namely:

• The sectors firms belong to. There may be capital-intensive and labor-intensive sectors.

• The regions where firms are located. A sector might be more productive in one region than in another because of the different regional penetration of innovation in capital and the different skill of the labor force.

To avoid a biased result with the use of our connectivity index, an analysis was undertaken on the database to see whether there was any consistent relationship between some firms' features and their productivity. In particular, an analysis was carried out to see whether the most 'labor-intensive' firms belonged to a particular sector or were located in a specific region; whether the largest firms were located in the same regions and in the same sector. The results of this analysis showed a completely random relationship among these variables. For this reason we have some confidence that the simple performance index measured as the 'labor productivity' could be used in our analysis.

The next sections are devoted to the empirical results regarding the existence of production network externalities.

Empirical Results

In this section we present empirical evidence for our research issue, whether network externalities play a role in the performance of firms and regions. The main focus of the analysis is identification of a possible correlation between the performance index and the connectivity index.

In light of our conceptual framework, we expect to find no correlation between the simple adoption of networks and services and the performance of firms. It is not the simple connection to a network which generates benefits to a firm. Rather, it is the use of these technologies which creates production network externalities to the networked firms.

In order to test the first hypothesis deduced from our conceptual framework, the simple connectivity index described in the previous section was constructed, i.e. the ratio between the real number of connections to the

NATIONAL RESULTS		
	Performance Index	Row Connectivity Index
Performance Index	1	0.069
Row Connectivity Index	0.069	1
RESULTS FOR THE NORTH		
	Performance Index	Row Connectivity Index
Performance Index	1	0.398
Row Connectivity Index	0.398	1
RESULTS FOR THE SOUTH		
	Performance Index	Row Connectivity Index
Performance Index	1	−0.0588
Row Connectivity Index	−0.0588	1

Table 1. Correlation coefficients between the Row Connectivity Index and the Performance Index by macro-areas

number of potential connections for each firm of our sample. A very simple performance index was chosen, representing the productivity of each firm and defined as the ratio between the turnover of firms in 1991 and the number of employees in the same year, as suggested in the previous section.

To be sure that the results are not biased by sector or size effects, the analysis has also been run to take into account the sectors firms belong to and the sizes of firms. The 'sector' variable has been introduced by running a multivariate correlation between the performance and connectivity indices and the sectors to which firms belong. The size variable has been taken into account by running the multivariate correlation in four different groups of firms of different size, in order to test whether the exploitation of network externalities was related to the dimension of firms. If the size of firms has an impact, we expect an increasing (decreasing) value of the correlation coefficient when the size of firms increases (decreases). This method has been applied also at a regional level. Multivariate analysis with sector and size variables allow us to separate network externality effects from the effects of economies of scale and innovative processes. If there is any relationship between the level of connectivity and the performance of firms, and this is independent from sector or size effects, then variations in the performance of firms can be mainly attributed to (production) network externalities.

A correlation analysis was run on these two indices at both national and regional level (Table 1). The Pearson correlation coefficient R confirms the first impression, having a value of only 0.069. With this value we can go a step further by claiming that almost no correlation exists between these indices. Our first hypothesis is thus confirmed, since the empirical analysis allows us to conclude that the simple adoption of these technologies as such has no effects on the performance of firms.

Results do not change when the size and the sectoral variables are introduced in the analysis. The multivariate correlation analysis which introduced the sectoral variable leads to a similar result for the correlation coefficient, which assumes a value of 0.08. When the analysis is repeated in the four groups of firms of different sizes (in terms of both employment and size), the correlation coefficient changes randomly and does not demonstrate any relation with the size of the firms.

At the regional level, our expectations appear to be verified. The Pearson correlation coefficients change to 0.398 for the north of Italy, and −0.058 for the south of Italy (Table 1). The regional dimension is important in explaining the results of the empirical analysis. The national result is an average value of the two regional analyses, which separately show a different pattern. For the south, the correlation is absent, with a value near zero and a negative sign. For the north of Italy, the situation undoubtedly improves, achieving 0.39 as a correlation value and thus showing a weak correlation between the two indices. This result confirms our hypothesis of the limited effect of adoption on the performance of firms. Results do not vary in the two regions when the analysis takes into account the sectors to which firms belong. In fact, the multivariate correlation analysis shows a similar correlation coefficient value: 0.4 in the north and 0.03 in the south. Moreover, the correlation run separately for the four groups of firms with different size does not show any clear relation between the dimension of firms and the correlation coefficient values.

If we adjust the connectivity index to the frequency of use of these services, the results of the correlation analysis at the national level (of Italy) show a still very low Pearson correlation coefficient of R 0.11 (Table 2). At the regional level, it appears that there is a better fit for a linear correlation in the case of the north than of the south. This impression is confirmed by large differences in the Pearson correlation coefficients, whose value varies from

NATIONAL RESULTS		
	Performance Index	Weighted Connectivity Index
Performance Index	1	0.11
Weighted Connectivity Index	0.11	1
RESULTS FOR THE NORTH		
	Performance Index	Weighted Connectivity Index
Performance Index	1	0.473
Weighted Connectivity Index	0.473	1
RESULTS FOR THE SOUTH		
	Performance Index	Weighted Connectivity Index
Performance Index	1	0.0856
Weighted Connectivity Index	0.0856	1

Table 2. Correlation coefficients between the Weighted Connectivity Index and the Performance Index by macro-areas

0.085 for the south to 0.473 for the north (see Table 2). These results show:

- The regional variation in correlation analyses is even greater in the case of the correlation between the simple adoption and the firm's performance. The national correlation value is nevertheless still very low because it averages an even lower R in the case of the south and a higher value for the north.
- As expected, the most developed regions are also the ones which gain more from network externality effects, while backward regions are not yet able to achieve economic advantages from their adoption.
- The use of these technologies is strategic for the exploitation of production network externalities. In northern Italy, where these technologies are used more frequently, the economic advantages from their adoption is certainly higher than in southern Italy.

Conditions to Exploit Production Network Externalities

Some doubts remain on the previous analysis. The first is to 'reveal the inner working' of the linkage between the connectivity and the performance index identified before, by defining the variables and the elements which characterize the relationship between the two indices of connectivity and performance. The analysis run in the previous section does not tell us why and under which conditions the correlation takes place. The second doubt is

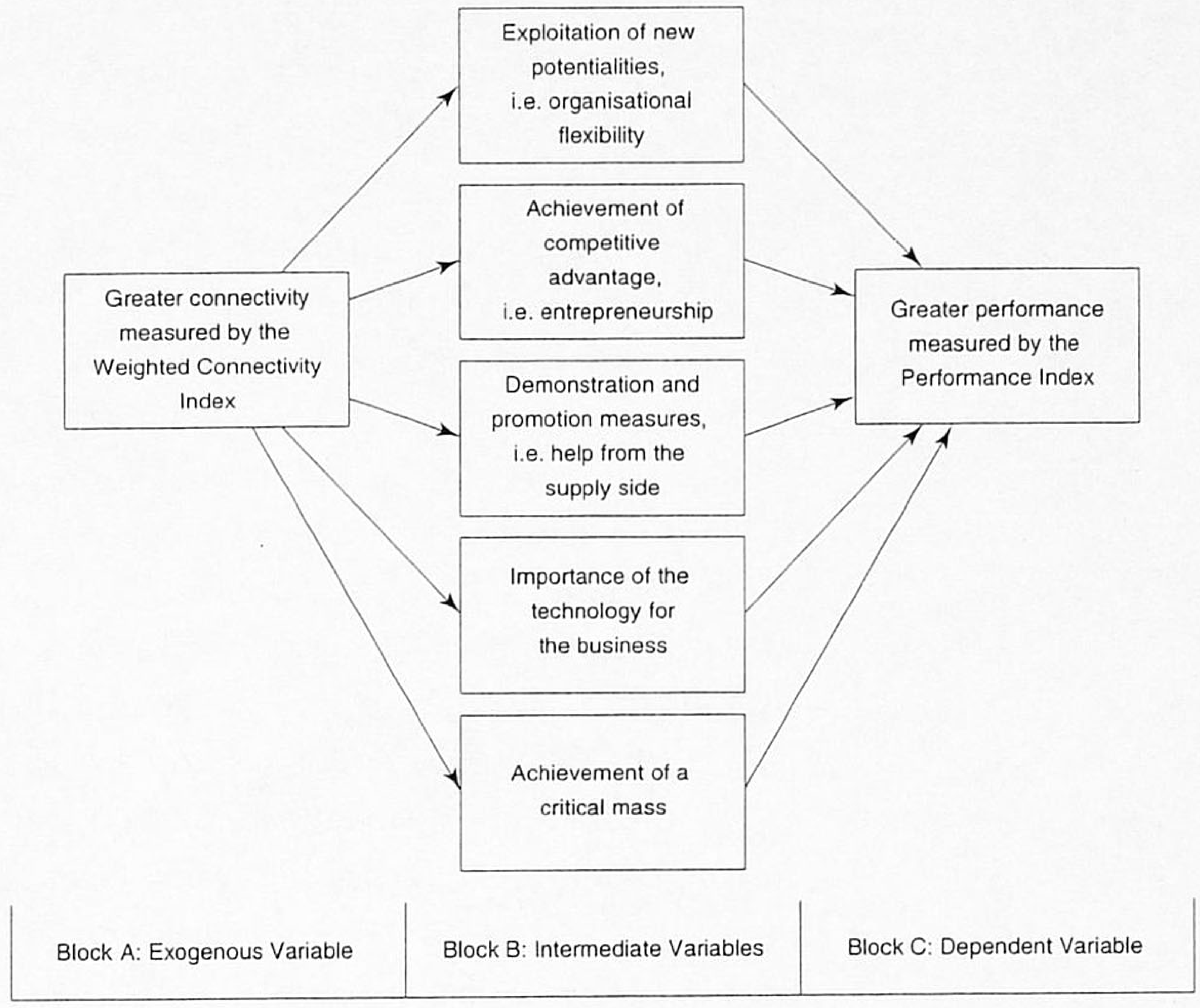

Figure 3. A general model for network externalities exploitation estimates

that at present the results show the existence of a correlation between the two indices, without showing the direction of causality. We have interpreted the results as the higher the connectivity, the greater the performance, but this statement could easily be expressed in reverse.

On the basis of a path analysis to be run in this section, these ambiguities are overcome by imposing and testing a clear causal path, starting from greater connectivity to better performance. On the basis of our conceptual approach, some conditions may be foreseen, which develop to avoid bottlenecks and barriers to the exploitation of production network externalities, on both the supply and demand side. Figure 3 summarizes our conceptual model for production network externalities. The upper part of the chart represents the conditions on the demand side in order to exploit better production network externalities, while the lower part summarizes the conditions on the supply side. When these conditions are present, we expect firms to be able to exploit the advantages from these technologies.

Our intention in this section is to explain the relationship between the connectivity index and the performance index. Other variables may have been taken into account, such as the size of the firms or the sectors they belong to, which may have a direct or an indirect effect on either the performance or the connectivity index. However, we restricted our analysis to some specific variables, presented below, for a number of reasons.

• From the most theoretical point of view, the variables used in our model represent those most commonly mentioned in the literature on telecommunications diffusion processes, having strong influence on the decision to adopt these new technologies.

• Again from a theoretical point of view, there is no reason why larger firms should have different contact patterns than small firms, as is also witnessed by the results where the size variable was insignificant with respect to the estimation of consumption and production network externalities. Larger firms may be more able to accept innovation, as is well known in theory, and this aspect is indirectly taken into account in one of the variables in our model, which reflects the innovative behavior of a firm.

• From a statistical point of view, a model with too many explanatory variables has low explanatory power. Thus, only those quoted in the literature as the most capable of explaining adoption processes were introduced in the model. Moreover, the good results achieved in the empirical analysis suggest that no important explanatory variable is missing.

A method we use is estimating path analysis models. They have an important characteristic: relations between variables must have an evident causal direction and this allows us to disentangle the link between the connectivity and the performance indices. As mentioned, the intermediate variables explain the conditions under which the correlation between connectivity and performance indices takes place. In particular, their presence virtually proves that the adoption of new technologies generates better corporate performance. To be sure that the direction of causality between the performance and the connectivity indices was appropriately identified, we estimated the causal path analysis model also by reversing the direction of causality shown in Figure 3, a model where greater performance was the independent variable, which explains greater connectivity. The poor results confirmed that our hypothesis was correct.

On the supply side, at least three conditions have to be present in order to allow firms to exploit production network externalities:

- A critical mass of adopters, especially for inter-related services, e.g. electronic mail. The user value of these technologies is related to the number of already existing subscribers. Our idea, tested in another study (Capello, 1994), is that the number of already existing subscribers is one of the most important reasons for joining networks and services. The existence of at least a certain level of subscribers is a necessary condition to stimulate cumulative self-sustained mechanism. If a critical mass is not achieved, the risk is that potential adopters are not sufficiently stimulated to adopt these technologies. In other words, the adoption process of these technologies has to be strongly supported by the supply until a critical mass is achieved.
- Constant assistance in the first phases of development from the supply side is needed, in terms of the technical, managerial and organizational support necessary for an innovative exploitation of these technologies. This process requires a strong effort by the subscriber, who frequently needs expert support from the supplier. The STAR program certainly has taken this aspect into account. Some specific measures were devoted to the implementation of 'demonstration and promotion actions' through specialized centers whose task was to develop a 'telematics culture' among potential users. However, in some countries such as Italy, these centers emphasized technical rather than organizational aspects. While these centers assured technical support to users, they did not provide adequate advice about problems and changes which have to be coped with in order to exploit production network externalities. We expect that this lack of organizational support will create a bottleneck in exploiting network externalities.
- Another crucial factor in exploiting production network externalities is clear identification of the way these technologies may be useful for business. As we explained, from a conceptual point of view, these technologies are complex and require a certain degree of organizational change to become useful to business. To stimulate demand, the supply side has to demonstrate the importance of these technologies for business.

Although this set of critical success conditions is required on the supply side, there are also some requirements of the demand side:

- Firms have to be highly flexible if they want to exploit production network externalities.

• Innovative behavior, or entrepreneurship, can establish competitive advantages through these technologies. Via learning and previous experience of innovation, a firm may have the necessary know-how to change in order to achieve competitive advantage. The higher the number of innovations already adopted by the firm, the greater the probability of exploiting production network externalities.

To be sure that the direction of causality between the performance and the connectivity index was the most appropriate one, we estimated the causal path analysis model also by imposing the reverse direction of causality to the one presented in Figure 3, a model where greater performance was the independent variable explaining greater connectivity. The poor results obtained have demonstrated again that our hypothesis was right.

For the north of Italy, the results are satisfactory. Figure 4 shows both the values of the estimated parameters and the T-Student test results for the estimated parameters (presented in brackets). In interpreting the results of both the north and the south of Italy, it should be kept in mind that all variables have been standardized with unit variance and mean zero, in order to be able to compare the relevance of individual parameters. Some conclusions can already be drawn:

• Almost all parameters are statistically significant, having T-Student values over 2.
• All estimated relations have the expected sign.
• The model itself fits very well with the given variables (P value = 0.01).

Our conceptual model thus appears to be confirmed: micro-conditions allowing firms to exploit network externalities are present in northern Italy.

A different result is indeed achieved for the south of Italy. As Figure 5 shows, the results of the same conceptual model are quite different and in fact are less satisfactory, as expected. At first glance one can immediately make a general remark that the model does not fit the empirical estimations. Most estimated parameters, apart from two, are not statistically significant, showing T-Student values below the critical value of 2.

In any other circumstances, this result would have been interpreted as a negative, destroying from an empirical point of view the conceptual framework underpinning these results. On the contrary, these results support our expectations: micro-conditions to exploit production network externalities seem not to be present in southern Italy. We can even argue that

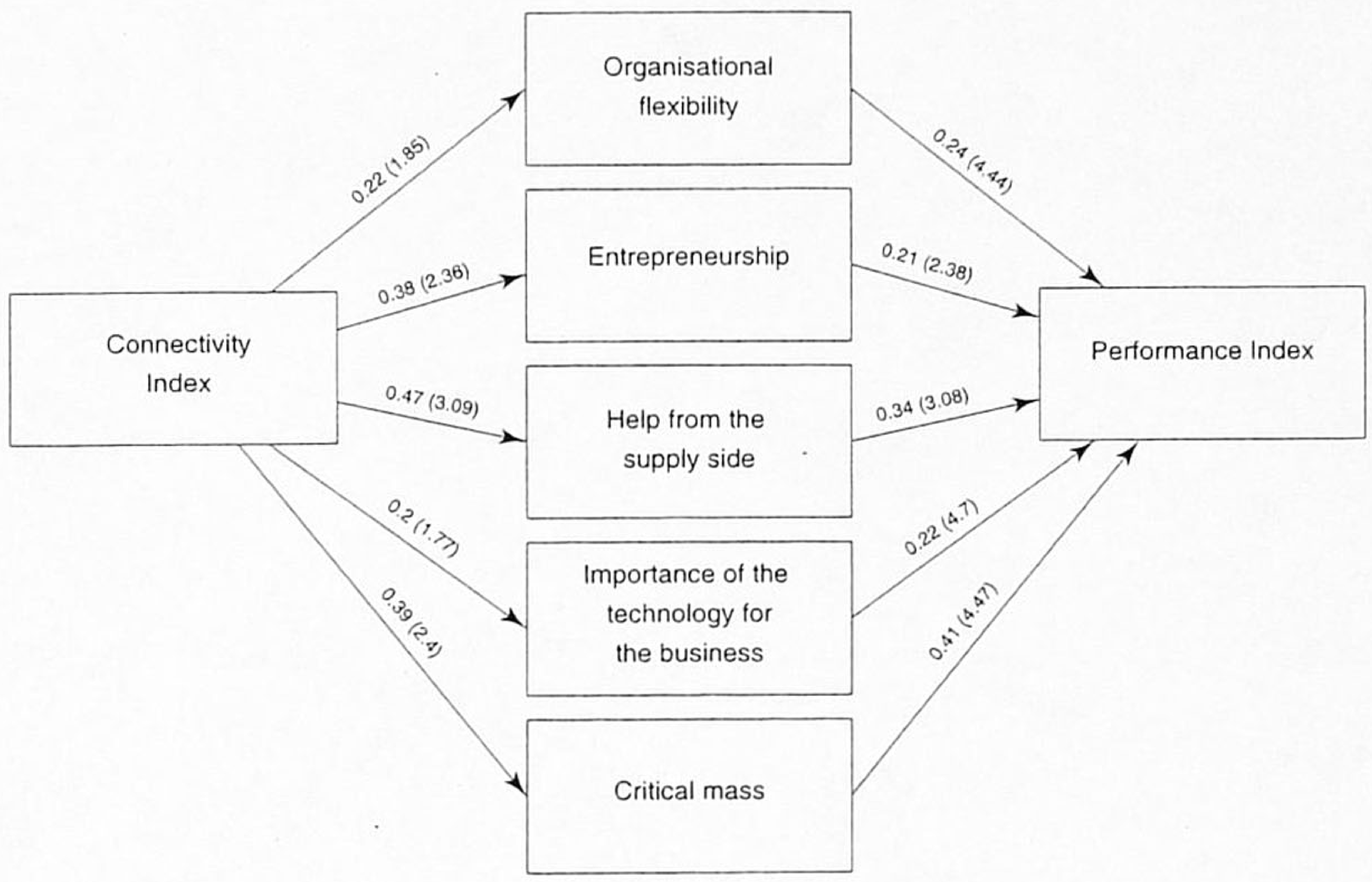

Figure 4. Estimated path analysis model for the north of Italy

with this analysis we have been able to identify the barriers and bottlenecks which exist in the exploitation of production network externalities and hinder the achievement of better economic and spatial performance via the application of advanced telecommunications technologies.

Conclusions and Policy Implications

The empirical analysis run in this study contains some policy implications regarding the effects these technologies have in reducing inter-regional disparities. In particular, a first crucial result is that mere accessibility to advanced telecommunications infrastructures and services does not necessarily lead to a better corporate and regional performance. The results in the south of Italy are representative in this respect, since the empirical analysis shows no correlation between greater intensity of these technologies and better industrial and regional performance. From such results one may be inclined to draw a negative conclusion about the effects that the STAR intervention program, run by the EC until 1991, has generated on the performance of local firms. However, such a conclusion is far too pessimistic and could be highly criticized for the following reasons:

- Evaluations of regional impact require a long-term perspective. Regional

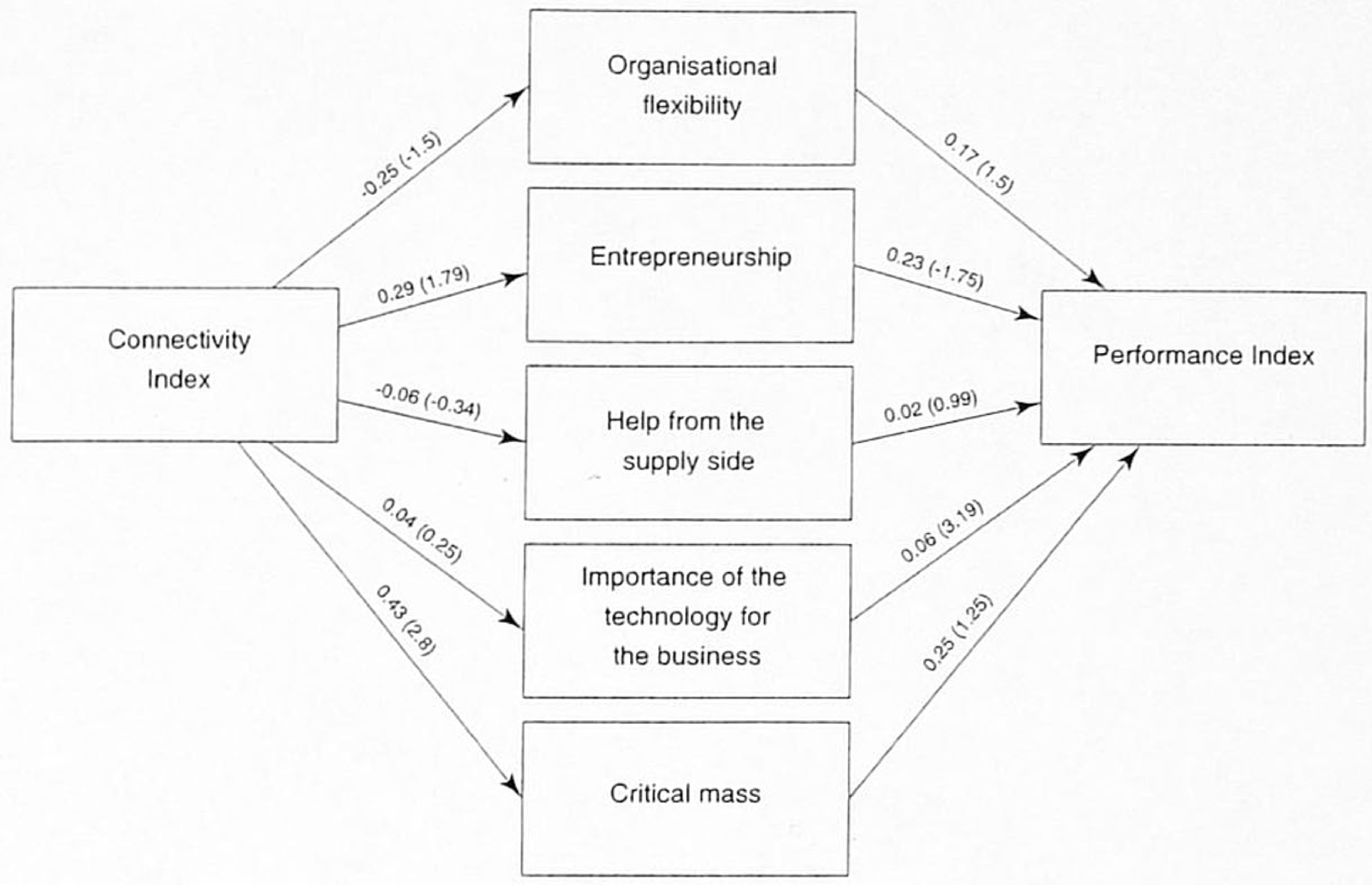

Figure 5. Estimated path analysis model for the south of Italy

effects occur in the long run, and only a long-term evaluation can really test the benefits of the program. Our analysis took place only a few months after the end of the program, when all the spin-off and spillover effects at regional level may still not have generated all their effects.

• In the short run, an evaluator can only be concerned with the potential of these technologies to influence regional performance. In this respect, this study is useful, since it emphasizes bottlenecks and barriers which hamper the exploitation of production network externalities by firms. The conditions put forward by our conceptual framework and tested in our empirical analysis suggest some policy recommendations. These should be considered when developing an infrastructure intervention policy like STAR, which was intended to decrease regional disparities.

The first crucial precondition to assure a sustainable adoption of these technologies (and thus greater real connectivity) is the achievement of a critical mass of adopters, especially for interrelated services such as electronic mail. The user value of these technologies is related to the number of already existing subscribers since the attraction for a new potential subscriber to join the network is the possibility of being linked to a great number of subscribers. A certain number of subscribers is necessary to stimulate a cumulative, sustainable mechanism. The number of subscribers needed to effect this mechanism varies according to the sectors to which firms belong. Some sectors are more inclined to accept the risk of a low number of subscribers, since telecommunications technologies are extremely important for their business, as was evident in our empirical analysis. A policy recommendation underlining the importance of a number of subscribers may appear rather too general, since the critical mass level is extremely difficult to be measured at an empirical level (Allen, 1988). However, it is our opinion that the general suggestion on the importance of the number of subscribers in a network has to be stressed in telecommunications development policy guidelines, since many programs on telecommunications implementation, at both European and national levels, have been shown to underestimate this strategic development tool, probably because of the high level of financial investments required to exploit it.

Another critical factor for achieving a great number of adoptions is clear identification of the way these technologies may be useful for business. By no means simple, they require certain organizational changes to become useful; requiring a strong effort by the subscriber, who often needs expert support from telecommunications organizations. The STAR program took this aspect into account. Some measures were devoted to the implementation of 'demonstration and promotion actions' through specialized centers whose task was to develop a 'telematic culture' among potential users (the so-called 4.2 measures). However, as the results underline, crucial elements in this process are not only the 'technical aspect' but also the 'organizational aspect', because of the complexity of integrating these technologies within the established business structure. From the results obtained, it seems that these centers promoted these services by underlining in most cases their technical capacities, and assuring technical support to firms. They did not, however, deal sufficiently well with organizational problems and changes which have to be borne in order to exploit these technologies in the best way.

The economic environment of the south is weak in those traditional crucial factors which stimulate the adoption of technological change. In the south, the economic environment is characterized by: a) a very high risk aversion by potential adopters, b) very limited competitive market forces, and c) a stable division of market shares. All these features define a very difficult environment where self-sustained adoption mechanisms of new technologies risk finding no stable ground in the short term and where for these reasons the usual incentive policies have to be extremely strong, especially in the first phases of the diffusion processes. The STAR program heavily subsidized networks and services during its early years (to the extent that these technologies were free of charge for the pioneering users). This incentive policy has turned out to be extremely useful. However, there has been no adequate policy underlining the potentials of these technologies in terms of business needs solutions or new market niches to be exploited. Provision of these complex technologies especially has to cover the organizational aspects, more than simple technical details. Moreover, successful provision requires identification of ways in which these technologies can be exploited to solve business needs or achieve new business goals. The organizational aspect and the business idea aspect have not been regarded as strategic factors for adoption; neglect of these two aspects could create serious bottlenecks in the adoption process and hamper the exploitation of production network externalities by firms and, via multiplicative effects, by regions.

All these remarks lead to the identification of policy guidelines for future intervention policies which have to be taken into account to achieve successful results.

First, it is possible to claim that the promotion policies of these technologies have to be based on a bridging mechanism between demand and supply, i.e. they have to be able to link business needs, or even potential business needs, to the existing technological potentials. Suppliers should be able to provide not only the physical infrastructure and technical support, but also the business angle on how to exploit these technologies on the basis of business needs of potential users. One way of dealing with this problem is to customize these networks and services as much as possible to the personal needs of potential users.

A second lesson from the STAR program is more related to the 'spatial circumstances' in which these technologies have to be promoted. A crucial resource for the development of these technologies is *entrepreneurship*. In other words, the presence of risk-aversion and non-competitive market structures discourages adoption of these technologies, since no market force exists under conditions which can stimulate firms to bear the organizational, managerial and financial costs necessary for successful adoption. Thus, local entrepreneurship turns out to be a strategic element for successful adoptions.

Innovative policies have to take this aspect into consideration, favoring, among other factors, local areas where entrepreneurial capabilities are available. Instead of supplying these technologies to all areas in less developed regions, as with STAR in Italy, innovative policies should be focused on the most technically and entrepreneurially dynamic areas. These 'local milieux', represent the most efficient and dynamic areas where a technology policy could lead in the long run to good results in terms of network externality exploitation. This modern view of intervention policies suggests that technology policy, when implemented without a territorial perspective, either results in a cumulative process of spatial concentration of technological development, or lazily remains inefficient, as it overlooks the adoption problems of small and medium-sized enterprises.

Another important aspect of technology policy for regional development is capacity to overcome local economic constraints. Telecommunications technologies are seen by users as a way to obtain knowledge not available locally, and which is typically derived from advanced economic areas. For this reason, the STAR program has been seen as crucial for shrinking physical and economic distance between backward and more advanced areas in the European Community. However, the way in which the program was run and managed, guaranteeing an advanced link in backward areas, has lost part of its attractiveness. The creation of a club of poor regions does not seem to be the right policy objective for ensuring locally sustainable economic development. In the Italian case, the implementation of advanced networks and services in the south, with no direct link to the north of Italy, has acted as a disincentive to adoption.

The impact of STAR on regional development was geared to overcoming bottlenecks and barriers hampering full exploitation of these technologies. The capacities of future intervention policies to solve these problems will determine the extent to which these technologies can influence regional performance in the future. For these reasons, it is vitally important to assure continuous provision of these technologies via the launch of a second intervention program. This would have two aims: a) to overcome the present bottlenecks and barriers in the adoption processes, taking into account the lessons learnt by the first phase of the program, and b) to achieve the expected positive effects on regional performance, at present hampered by low levels of both adoption and use.

Notes

1. This paper draws upon the results of a large research project undertaken by the authors. The complete results of the study are published in Capello (1994). The first author wishes to acknowledge financial support by Italian National Research Council projects directed by Prof. Roberto Camagni (Contracts No 94.01350.PF96 and 94.00560.CT11). Though the paper is a joint research work of the two authors, R. Capello has written the second, third and fourth sections, while the remaining sections have been jointly written.
2. A vast literature still deals with this debate. To quote just a few examples, see Allen, 1990; Bradley and Hausman, 1989; Brock, 1981; Camagni and Capello, 1989; Capello, 1991; Crandall and Flamm, 1989; Curien and Gensollen, 1987; Foreman-Peck and Mueller, 1988 and 1990; Mueller, 1991; Phillips, 1990; Philip, 1990; Von Weizsaecker and Wieland, 1988.
3. The role of telecommunications technologies in the economy has been largely studied and conceptualized at the Center of Urban and Regional Development Studies of the University of Newcastle. See, among others, Gillespie et al., 1989; Gillespie and Hepworth, 1986; Goddard et al., 1987; Williams and Taylor, 1991.
4. An extensive critical review of the literature on network externality is presented in Capello (1994).
5. The potential connection of a firm is defined as the total number of existing telecommunications services offered to firms.
6. In this study, 'row' connectivity index means the connectivity index constructed taking into account only the adoption data. This index is different from the so-called 'weighted' connectivity index which is derived taking into consideration the 'frequency of use' of adopted telecommunication services. This index was constructed by multiplying the adoption data with a weight derived by the data on the frequency of use: a weight of 1 was given to services used every day, 0.7 to services used weekly, 0.3 for services used monthly and, finally, 0.1 for services used annually.

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